CONTROL SYSTEMS FOR MANAGING ENERGY CONSUMPTION

All the mechanical and electrical equipment in a building must be used with proper controls if it is to function as the designer intended. Although it is theoretically possible to operate such equipment manually, to do so could lead to chaos as a result of human error.

The earliest controls were fairly simple devices such as switches, thermostats and timers. Today many buildings are completely controlled by sophisticated computers. Such systems, when properly programmed, greatly reduce the possibility of human error. They can be designed to perform a wide range of functions, including the control of all heating and cooling equipment, lights, and fire and safety systems. In addition, they can provide visual monitoring of such items. The computers can also log the hours of use of various equipment. This information is of value to operating staff when they are scheduling maintenance or replacement of equipment.

Although we might consider that the prime purpose of controls in a building is to keep the building as comfortable as possible, we can also use controls to ensure that buildings are operated as economically as possible. This applies especially to the use of electricity.

READING UTILITY BILLS

The hydro bill for a non-residential customer consists of two parts:

(a) a demand charge and (b) an energy charge.

The energy charge is simply the total energy, in kilowatt-hours, used in the billing period multiplied by a rate (or rates) per kilowatt-hour.

The demand charge is based on the maximum load, in kilowatts, for a given time interval (usually 20 minutes) during the billing period. It does not matter whether this peak-demand load lasts for 4 hours, 200 hours or only 30 minutes during the billing period. The result will be the same insofar as the demand charge is concerned. The demand at other times may be considerably lower. The reason for the charge is that the utility must have sufficient capacity in all its equipment (distribution, generation, transformation, etc.) to supply this peak any time it is demanded.

Since the demand charge is a large part of the monthly electrical bill, it makes good economic sense to investigate ways to minimize it. Although much of the equipment that uses electricity must be on at specific times, some of it can be turned on at the will of an operator. In other words, it is possible to schedule certain loads so that unplanned high peak demands are avoided. Some of the equipment that readily comes to mind are hot water heaters, fresh-air-supply fans, snow-melting systems, heaters in unoccupied spaces and outside lighting.

It is possible that a building operator could review the uses of electricity in his building and attempt to schedule the operation manually so as to limit the total kilowatt demand at any given time. However, the possibility of human error enters the picture again, and, as noted above, he only has to be wrong for 20 minutes to undo all his efforts for the rest of the month. It is much safer and easier to use a control device to perform this task.

Electrical-demand control systems are available in a wide range of types. Some are relatively simple, stand-alone devices; others are but one component in a large, complex building-automation system. Most peak-load control devices are designed to monitor the total electrical demand of the building continuously. A predetermined peak value and order of priority are entered in the control. If the building load approaches this predetermined value, the control will begin to drop off certain electrical loads in the order specified by the building operator. Once the total load has dropped below the peak value, the control will allow the equipment that was turned off to be switched on again.

CONTROL OF ELECTRICAL DEMAND YIELDS FAST PAYBACK

A Peterborough developer, A.O.N., Inc. operates a number of large residential-commercial buildings. In the mid-seventies a complex of three buildings, known as the "Citi Centre", was built in the downtown of the city. The complex consists of 310 apartment units and some 2,500 square metres (27,000 square feet) of office and retail space on the ground floor. The buildings are all-electric. Although this concept provided for the ultimate in flexibility and low maintenance, it was thought that the total operating costs were somewhat high. The average electrical bill for the three properties was over $200,000 a year. One reason for the large bill was that no attempt had been made to control the demand.

In 1984 an energy-management system, the "Energist", was engineered and installed by BFR Industries in the three buildings. The main purpose of the system is to minimize the total electrical demand of each building. As a pre-set value of kilowatt demand is approached, the control drops off selected load components to maintain the peak below the pre-set value.

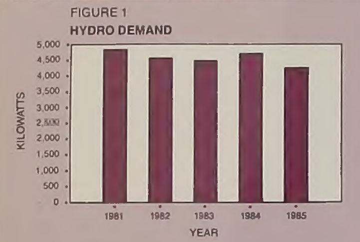
A number of non-priority loads are controlled. They include all hot water tanks, snow-melting cable in the ramps, and space heating in the corridors and common areas. In addition to controlling peak electrical demand, the Energist sets back space temperatures in stairwells and corridors at night and schedules the operation of outside lighting.

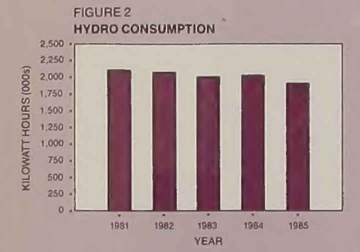
The installation of the control system required very few wiring changes in the building. The control device operates by transmitting a radio signal over the power line to the equipment being controlled. A responder at the controlled equipment receives the signal and cuts off the desired item.

As well as the Energist system, the three buildings have an additional control device. The Peterborough Utilities Commission uses a radio control on the water heaters. This can, if necessary, override the Energist and cut off the water heaters at times of the utility's own peaks. Since this operation saves the utility money on its cost of power, a discount is passed on to A.O.N.

The cost of the Energist system, approximately $50,000, was recovered in under two years from savings on the electrical bills. These savings approach $27,000 a year. The discount from the utility adds another $13,000 saving.

Hugh Smith, Vice-President of A.O.N., says, "It's working very well. In fact, we are now looking at putting in the same type of energy control system in some of the other buildings that we operate."





Note: The Energist was installed in 1984.

245 Charlotte Street, Peterborough Citi Centre. Electricity use and costs before and after controls were installed.

IMPRESSIVE ENERGY SAVINGS FOR SMALL BUILDINGS

Setback controls on heating equipment and timers on exhaust fans paid for themselves in a year and a half at Stratford's Tourist Information Centre.

Buildings do not need to be enormous nor do controls have to be highly sophisticated to achieve energy savings. The City of Stratford proved this. Among the buildings that it operates is a 111-square-metre (1,200-square-foot) tourist information centre. This glass and steel structure, built in 1978, is situated downtown on scenic Lake Victoria. It is actually the second floor of a building that is used for boat storage.

The centre is in use 11 hours a day, seven days a week, from late March until the end of October. Excluding the boat-storage area, there are about 88 square metres (950 square feet) of conditioned space. Although this space is used for only eight or nine months, it is kept heated all winter. The main uses of electricity are

- Electric heating – 7 units totalling 18 kW
- Air conditioning – 2 units, each 13,500 BTU/hr. capacity
- Exhaust fans – 3 units, each 100 CFM capacity.

In 1984, Cheryl Nash, Energy Auditor for the City of Stratford, did an audit of the facility and recommended the following measures designed to save money on the energy bill:

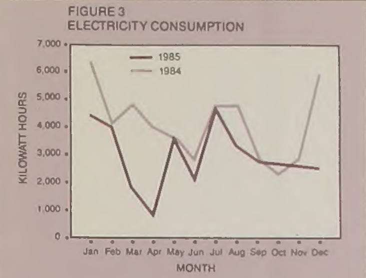
- Caulking the windows
- Weatherstripping two doors
- Sealing around the air conditioners
- Adding more insulation
- Installing setback controls for both the heating and cooling equipment
- Installing timers for the washroom exhaust fans.

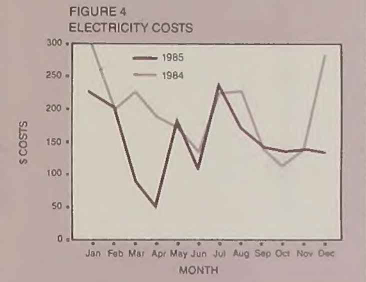
Before the timers were installed, the exhaust fans were on all the time the building was occupied. Not only did this waste electricity for the fans, but it also meant that the air exhausted during unoccupied periods had to be replaced by fresh, heated (or cooled) air. The timers now turn the fans on for seven minutes of every half hour.

Before the installation of the setback controls, the building was heated to 21°C (70°F) for 24 hours a day. The building is now kept heated to about 10°C (50°F) during the winter in order to prevent moisture problems. During the spring and fall the temperature is allowed to drop to 17°C (63°F) at night.

The cost of the setback thermostats and timers was $471; the total cost of all the measures undertaken was $968. The setback thermostats and timers probably provided the largest reduction in the energy use.

How successful was this retrofit? Ms. Nash has kept monthly records of how much electricity was used, before and after, and the results are very rewarding. For 1985, the reduction in electricity use meant a saving of $659 (using 1985 rates) compared to the previous year. This is a payback of one and a half years for the total retrofit. (See Figure 3).





Stratford Tourist Information Centre. Electricity use and costs before and after controls were installed.

ENERGY MANAGEMENT IN PERTH COUNTY SCHOOLS

Northwestern Secondary is one of three schools reaping savings of $52,000 per year in total from an energy-management system.

The Perth County Board of Education administers a number of elementary and high schools in an area encompassing Mitchell, Stratford and Listowel. Phil McCotter, Operations Manager, oversees energy matters from his office in Stratford. When he assumed this position about three years ago, he began to look for ways to conserve energy in the schools. With the emphasis on saving heating energy, the idea of automated energy management of various energy systems seemed a good idea. Prices were obtained from a number of suppliers of energy-management systems and eventually a design proposed by Johnson Controls was chosen. The systems were installed in three high schools with a total area of 41,000 square metres (440,000 square feet).

Each of the schools has a micro-processor-based panel, which is connected through a telephone link, to a personal computer in Mr. McCotter's office in Stratford. The micro-processors control a number of energy-intensive systems in the schools. Included are start/stop functions for all air-handling equipment. In addition, the boiler hot water temperature is scheduled according to outdoor temperature and also time of day. During unoccupied periods the water temperature is set back further. For example, when the outdoor temperature is −18°C (0°F), the hot water temperature is 82°C (180°F), but when the outdoor temperature is 17°C (62°F), the boiler heats the water to only 38°C (100°F). Once a school is vacated for the day a computer shuts off all fans and heating coils. Reactivation is possible, however, if the indoor temperature falls below 17°C (62°F). Although Mr. McCotter has the prime control of the various operations, there is provision for local override by individual school maintenance staff should off-hours use of a building require it.

At present the lights in each school are controlled manually by the school staff, but plans are underway to incorporate this operation into the energy-management system. In regard to lighting, Mr. McCotter notes that recently 80 500-watt incandescent lamps in the gymnasium at Northwestern Secondary School in Stratford were replaced with 80,4-lamp, 40 watt-fluorescent fixtures. The expected payback period is about two years.

The energy-management systems in the three high schools were installed during the summer of 1985 on a three-year lease-purchase arrangement. The leasing agreement calls for payments of $3,276 a month for the first 24 months and $1,927 a month for the rest of the contract. At the end of three years the board will own the systems. Mr. McCotter chose a leasing agreement because Johnson Controls would guarantee energy savings not less than the leasing costs.

Calculations by Mr. McCotter reveal that first-year savings exceed the leasing payments of $39,000 by $13,000. Gas use in the three schools has dropped by 15 to 23 per cent (taking weather variations into account). The annual saving was $52,000.

The school board is very pleased with the results of the energy management systems, and a similar system was installed in a new high school in late 1985 and in another school in March of 1986. Systems are being designed for two more schools. The latter installations will all be purchased outright.

FIGURE 5
ELECTRICITY CONSUMPTION

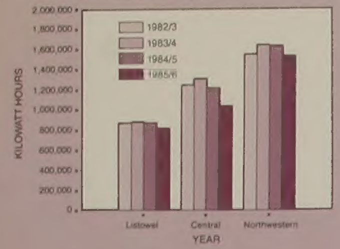
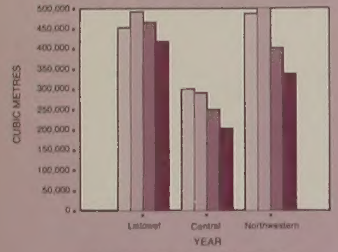


FIGURE 6
NATURAL GAS CONSUMPTION



Note: Systems operational by mid-October 1985

Perth County Board of Education. Savings appear in 1985/6 as a result of energy-management systems installed in three high schools.

BETTER CONTROL OF HVAC PLUS LOWER COSTS

In only 9 months this Canada Trust office in Ottawa recovered the cost of its energy-management system.

The Canada Trust property on Metcalfe Street in Ottawa is a seven-storey office building of approximately 5,100 square metres (55,000 square feet). The heating and cooling systems use both air and water. Before the control system was installed, the hot water temperature was varied according to the outdoor temperature. Individual dampers in the various rooms or areas were activated by local thermostats to mix hot and cold air for the desired final temperature.

The building management staff felt that, although the system worked well enough, it was not energy-efficient. Brian Boyle, Property Manager for Canada Trust, reports that the company's experience with automated building-management systems in other buildings of theirs prompted them to consider such a system for the Ottawa building. The one they chose was an Energist system by BFR Industries costing approximately $28,000 installed. All space temperature and controls are on an on-off schedule. Space temperatures are set back 5°C (10°F) at nights and on weekends during the heating season. During the warmer months the water chiller, which provides the building cooling, is switched off from 6 p.m. to 6 a.m. and all day on weekends. All air handling units are also turned off between 6 p.m. and 6 a.m. and all day on weekends throughout the year. The fans can be energized to supply heat if the indoor air temperature drops during unoccupied periods.

Canada Trust also supplies heating and cooling to an adjacent building and uses its Energist system to provide similar controls to that building.

Energy use in the building has been carefully monitored by Canada Trust personnel. Mr. Boyle says, "It's great. We had a payback of about nine months". Before and after records of oil and electrical consumption attest to his remarks. (See Figures 7 and 8)

FIGURE 7
ELECTRICITY CONSUMPTION

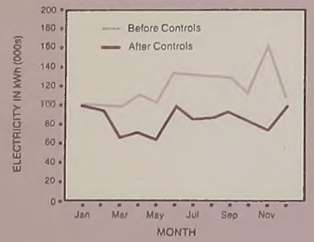
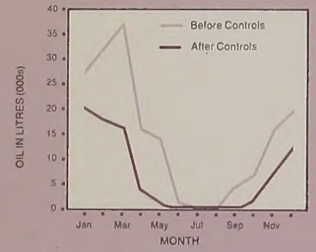


FIGURE 8
OIL CONSUMPTION



Canada Trust, Ottawa. Significant reductions in oil and electricity consumption result from automatic building controls.

PROJECT SUMMARIES

Citi Centre, Peterborough
Total Floor Area –
(Three buildings) – 24,441 square metres (264,000 square feet)
Cost of Project – $50,000
Estimated Annual Savings – $27,000
Payback – 1.9 years

Tourist Information Centre, Stratford
Total Floor Area – 88 square metres (950 square feet)
Cost of Project – $968
Estimated Annual Savings – $659
Payback – 1.5 years

Perth County Board of Education
Total Floor Area – (three schools) – 41,000 square metres (440,000 square feet)
Cost of Project – (first year leasing cost) – $39,000
Estimated Annual Savings – $52,000
Payback – 0.75 years

Canada Trust Co., Ottawa
Total Floor Area – 5,111 square metres (55,000 square feet)
Cost of Project – $28,000
Estimated Annual Savings – $37,120
Payback – 0.75 years

For further information contact:

Call (416) 965-6471
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Call the operator and ask for Zenith 80420

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Control Systems for Managing Energy Consumption

In the Citi Centre, an office, retail and residential complex in downtown Peterborough, an energy-management system controls peak electric demand, sets back space temperatures and schedules outside lighting. (Photo is courtesy of Ontario Hydro.)

Ontario
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